

1 SOLID-STATE IMAGE PICKUP APPARATUS WITH HIGH-SPEED
 PHOTOMETRY AND A SIGNAL READING METHOD THEREFOR

BACKGROUND OF THE INVENTION

5 **Field of the Invention**

 The present invention relates to a solid-state image pickup
apparatus with high-speed photometry and a signal reading method
therefor, more particularly to a solid-state image pickup
apparatus, which includes an array of photosensitive cells
10 integrated in higher density and arranged obliquely adjacent
to each other, that is , in the so-called honeycomb structure
having the lines or rows of cells offset from each other by
a length equal to the half of the pitch of the cells in line
or row, to accomplish an increased resolution, and which is
15 advantageously applicable to an electronic still camera, an
image input apparatus and the like.

Description of the Background Art

20 With reference to a solid-state image pickup apparatus
taking the so-called honeycomb arrangement, various kinds of
proposals have been disclosed in Japanese patent publication
No. 31231/1992, Japanese patent laid-open publication Nos.
77450/1994 and 136391/1998. In Japanese patent publication
No. 31231/1992, first electrodes meander along photosensitive
25 cells which are arranged in the offset manner, so as to form
a wavy shape pattern, and second electrodes are formed in
another wavy pattern opposite in phase to the former. Other
photosensitive cells are arranged in a region where the first
and second electrodes separate so as to enable a signal to
30 be read out from each cells via means for selectively coupling
with the second electrodes, in response to an enable signal
supplied to the first electrode, thus further increasing the
resolution and the sensitivity of the solid-state image pickup
apparatus from conventional. In the publication, the

1 *shape* photosensitive cells is exemplified as formed octagonal.

5 In Japanese patent laid-open publication No. 77450/1994,
the shape of photosensitive cells is formed as a square which
is one of diamond shapes, and each side thereof forms an angle
of 45 degrees in a vertical direction, so that its aperture
ratio is made to be high, thus miniaturizing the solid-state
image pickup apparatus. Particularly, by adopting a honeycomb
arrangement, an increase in a vertical resolution is achieved.
10 Moreover, a micro-lens is disposed on each photosensitive cell,
thus increasing a light receiving efficiency.

15 In Japanese patent laid-open publication No. 136391/1998,
meandering charge transfer devices of two lines are arranged
between photoelectric conversion devices in a column direction,
which are disposed so as to be adjacent to each other in the
same row and relatively shifted by approximately the half of
the interval between themselves in the adjacent rows, and
the charge transfer devices are used for transferring the charge
20 from the photoelectric conversion devices obliquely adjacent
to each other. A spurious signal aliasing such as moiré is
suppressed while achieving a high-density integration of the
photoelectric conversion devices and an increase in a
photoelectric conversion efficiency.

25 In the foregoing Japanese patent publication No. 31231/1992
and Japanese patent laid-open publication No. 77450/1994,
attention is paid only to the structure of the device in aiming
at a high-density integration. Moreover, in Japanese patent
30 laid-open publication No. 136391/1998, descriptions for the
structure and the shape of the device and the positional
relation of the color filters are made. Then, descriptions
of whole-pixel reading out using these relations are made.

1 *ins*
82 By the way, it is apprehended that a high-density
integration takes times for a reading out of signal charge
obtained by a photoelectric conversion. For example, in a
5 mode of controlling a light measurement or a photometry in
which an automatic focus adjustment (AF) and an automatic
exposure (AE) control are performed, there are demands for
shortening a time required for reading out the signal charge
and for finishing a preparation for an image pickup without
10 delay. For photosensitive cells, the high-density integration
of the image pickup devices and shortening of the time of the
signal reading out are antinomic demand, which are contradictory
to each other.

15 Particularly, when the signal is read out from the
photosensitive cells adopting a honeycomb arrangement in the
mode of controlling a light measurement, a breakthrough by
a different method from conventional methods is needed.

SUMMARY OF THE INVENTION

20 It is therefore an object of the present invention to
provide a solid-state image pickup apparatus free from the
drawbacks of the background arts and short in a time of a signal
reading out in the case of a light measurement control in spite
of a high-density integration of image pickup devices, and
25 a signal reading out method therefor.

30 According to a solid-state image pickup apparatus of
the present invention, in a mode set by a mode setting section,
a system control section controls a drive signal generator
to generate a drive signal. Light from an objective imaging
field is incident onto an image pickup device through a color
separation filter having at least three separated colors, color
filters of at least one of the separated colors being arranged
in the column direction. The image pickup device

1 photoelectrically converts the incident light by each of
photosensitive cells incorporated therein, receives the drive
signal on a signal reading out gate, and performs a transfer
of signal charge. A signal reading out only for the one
5 separated color is in turn performed taking account of the
arrangement of the color filter segments of color separation
filter. Thus, in the case of a high-density pixel integration,
a time required for reading out the signal is shortened. When
a signal is read out from the image pickup device and
10 information on the automatic focus AF, for example, is detected,
time required for the signal reading out, which was taken too
much in the past, can be avoided. Use of an optical sensor
and the like dedicated for a light measurement is made
unnecessary.

15 According to the method of a signal reading out, one of
whole-pixel reading out mode of reading out signal charge of
at least three separated colors and the specifying reading
out mode of reading out the signal charge only of one of the
20 separated colors is selected, and in response to this selection
a drive signal is generated for operating image pickup device
at a predetermined timing, which is used for reading out signal
charge. A destination supplied with the drive signal is
selected, to which the drive signal is in turn supplied.
25 Moreover, incident light is respectively separated to at least
three colors, and the incident light which was subjected to
the color separation in the color separation step is received
by a plurality of photosensitive cells. After this image pickup
step, in a specifying reading out mode, the signal charge read
30 out only from the photosensitive cells corresponding to the
one separated color among the plurality of photosensitive cells,
undergoes a field shift by the drive signal, and then obtained
signal charge is transferred in a column direction. The signal
charge is then transferred in a horizontal direction after

1 having repeated line shift of the signal charge. Thus, compared
to the signal reading out in the whole-pixel reading out mode,
the signal charge is read out only from the photosensitive
cell of the specified one of the separated colors, thus
5 significantly reducing time required for the signal reading
out. For example, this method can be used in controlling a
light measurement of the AF even in an application in which
pixels are arranged with a high-density integration.

10 BRIEF DESCRIPTION OF THE DRAWINGS

The objects and features of the present invention will
become more apparent from consideration of the following
detailed description taken in conjunction with the accompanying
drawings in which:

15 FIG. 1 shows a way how to combine FIGS. 1A and 1B with
each other;

FIGS. 1A and 1B are block diagrams showing a schematic
constitution of a solid-state image pickup apparatus according
to the present invention when the solid-state image pickup
20 apparatus is applied to a digital still camera;

FIG. 2 is a schematic plan view useful understanding the
relationship between the vertical transfer paths and
photosensitive cells arranged in the form of a honeycomb in
the image pickup device of FIG. 1A, when viewing from its light
25 incident side;

FIG. 3 is a schematic plan view showing an arrangement
of color separating filters adopting a honeycomb type G square
lattice RB complete checkered pattern, in which the color
separation filters are arranged integrally with each other
30 on the light incident side of the image pickup device shown
in FIG. 1A;

FIG. 4 is a schematic plan view showing the connections
of the photosensitive cells, signal reading out gates, transfer
devices on the vertical transfer paths and horizontal transfer

paths, and drive signals supplied to them;

FIG. 5 is a timing chart showing a vertical synchronous signal, a vertical timing signal and a transfer gate signal when a whole-pixel reading out is performed by the drive signal generator shown in FIG. 1B;

FIG. 6 is a timing chart showing the vertical synchronous signal, the vertical timing signal and the transfer gate signal with the leading edge portion of the vertical synchronous signal of FIG. 5 is depicted in an enlarged scale;

FIG. 7 is a timing chart illustrating the vertical synchronous signal, a horizontal synchronous signal, the vertical timing signal, the transfer gate signal, a drive signal and a potential generated by the drive signal in the vicinity of a leading edge portion of the horizontal synchronous signal shown in FIG. 6 in an enlarged scale;

FIG. 8 is a timing chart useful for understanding the phase relationship between the vertical timing signals used for generating signals of a four-phase drive in the image pickup device shown in FIG. 1A;

FIG. 9 is a timing chart depicting the vertical synchronous signal, the horizontal synchronous signal, the vertical timing signal and the transfer gate signal, which are generated by a signal generator when signal charge only for a color G is read out in the image pickup device shown in FIG. 1A in a mode of controlling a light measurement;

FIGS. 10A, 10B and 10C are schematic views showing the states of field shift, vertical transfer and horizontal transfer in reading out signal charge in response to a drive signal which is supplied based on the signal generated by the signal generator shown in FIG. 9;

FIGS. 11A and 11B are schematic views showing the states of vertical transfer and horizontal transfer, which are performed after the signal reading-out of FIGS. 10A, 10B and 10C;

1 FIG. 12 is a schematic view useful for understanding the
positional relationship between photosensitive cells from which
the signal charge in FIGS. 10A through 11B is read out and
photosensitive cells from which the signal charge in FIGS.
5 10A through 11B is not read out;

FIGS. 13A-13D are schematic views showing the states of
vertical transfer and horizontal transfer in an improved
procedure of thinning down lines of FIGS. 10A through 11B;

10 FIG. 14 is a schematic view illustrating the state of
the procedure continuing from the procedures of the improved
thin down lines of FIGS. 13A-13D;

15 FIG. 15 is a schematic view plan showing a specified range
on the photosensitive array to be read out by the image pickup
device of FIG. 1A in an AF adjustment in the mode of controlling
a light measurement;

20 FIG. 16 is a schematic plan view showing the connections
of the photosensitive cells, signal reading out gates, and
transfer devices on vertical transfer paths and horizontal
transfer paths when the signal charge only for a color G is
read out from a specified range in FIG. 15, together with the
drive signals supplied and them;

25 FIG. 17 is a timing chart showing a vertical synchronous
signal, a vertical timing signal and a transfer gate signal,
which are generated by a signal generator when the image pickup
device of FIG. 16 is driven;

FIG. 18 is a timing chart showing among the vertical
synchronous signal, the vertical timing signal and the transfer
gate signal with the portion of a leading edge of the vertical
synchronous signal of FIG. 17 in an enlarged scale; and

30 FIG. 19 is a timing chart depicting the vertical
synchronous signal, the horizontal synchronous signal, the
vertical timing signal, the transfer gate signal, and the drive
signal with the portion of a leading edge of the horizontal
synchronous signal of FIG. 18 in an enlarged scale.

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DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of a solid-state image pickup apparatus will be described with reference to the accompanying drawings below.

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With a solid-state image pickup apparatus of the present invention in which an array of photosensitive cells is integrated in a high-density in the form of the so-called honeycomb arrangement, in order to meet the requirement for a high-speed operation of an automatic control of AF, the period of time required for reading out signals is further shortened in an image pickup device in which a plurality of photosensitive cells are arranged, from the time required for reading out all pixel signals by using only one color of at least three separated colors, more specifically in the embodiment by using only a color G among the primary colors RGB. Particularly, by specifying a signal reading out region for measurements, the solid-state image pickup apparatus is characterized in capacity of the signal reading out at further high-speed.

The application of the solid-state image pickup apparatus of the present invention to a digital still camera 10 will be described. Illustrations and descriptions for portions which have no direct pertinence to the present invention are omitted for simplicity. It should be noted that signals are designated by the same reference numerals as those connection lines on which the signals appear.

As shown in FIGS. 1A and 1B, the digital still camera 10 comprises an image pickup system 10A, a signal processing system 10B, a drive signal generation system 10C, a signal output system 10D, a mode setting section 10E and a system control 12.

1 The image pickup system 10A includes a optical lens 102,
an image pickup device 104, an AF control 106 having a focus
adjustment mechanism, and an AE control 108 having an aperture
5 mechanism (not shown) for shielding incident light perfectly
may be provided on the light incident side of the image pickup
device 104. The optical lens 102 is adapted for receiving
the incident light from an object field so as to focus the
image of the object on a photosensitive array of the image
10 pickup device 104.

 The image pickup device 104 has a structure that a
plurality of photosensitive cells 104a for performing a
photoelectric conversion for the incident light supplied thereto
15 are two-dimensionally arranged in row and column directions
in a honeycomb-like manner so as to form a photosensitive array
(FIG. 2). In the honeycomb-like structure, the respective
photosensitive cells 104a are shifted or offset from other
photosensitive cells obliquely adjacent thereto by a length
20 equal to the half of the pitch thereof in the row and column
directions. The honeycomb-like structure does not mean the
shape of the photosensitive cell. It should be noted that
the pitch means, for example, the distance between the centers
of the adjacent two photosensitive cells in the row or column
25 direction. In the image pickup device 104, on the surface
of the photosensitive cells 104a, a single plate of color
separation filter CF is formed integrally to separate colors
of the incident light, which correspond to the respective
photosensitive cells 104a.

30 By the arrangement of filter segments in the color
separation filter CF, for example, the incident light which
has been separated in color so as to possess attributions of
the primary colors RGB is allowed to be incident onto the

1 respective photosensitive cells 104a. This arrangement is
shown in FIG. 3. The color separation filter CF is integrally
formed as a part of the image pickup device 104. In FIG. 3,
the three primary colors RGB are illustrated by symbols R,
5 G and B expressing colors. In the arrangement of the color
filter segments R, G and B shown in Fig. 3, the color G is
arranged at the cross-points of a square lattice, and the colors
R and B are arranged in an RB complete checkered pattern in
which the same color filter segments are arranged diagonally
10 interposing them between the color filter segments G. For
this reason, this color filter arrangement is hereinafter called
a honeycomb type G square lattice RB complete checkered pattern.
The image pickup device 104 outputs an image pickup signal
10a to the signal processing system 10B.

15 In the illustrative embodiment shown and described above,
the single plate of color separation filter CF is of the
honeycomb type G square lattice RB complete checkered pattern
composed of the RGB filter segments. The present invention
20 is however not restricted to the specific type of color filter
described above but advantageously applicable to other filter
systems of complementary colors, such as the honeycomb type
G square lattice YeCy complete checkered pattern in which for
the color filter segments R, G and B of the honeycomb type
25 G square lattice RB complete checkered pattern, replaced are
the color filter segments of Yellow Ye, green G and cyan Cy,
respectively, and the honeycomb type Gray or W square lattice
YeCy complete checkered pattern in which for the color filter
segments Ye, G and Cy of the honeycomb type G square lattice
30 YeCy complete checkered pattern, replaced are the color filter
segments of Yellow Ye, gray Gray or white W, and cyan Cy,
respectively.

The constitution of the image pickup device 104 will be

1 further described. The image pickup device 104 operates in
response to a drive signal 122a output from the drive signal
generation section 10C. Each of the photosensitive cells 104a
5 is constituted by a charge coupled device (hereinafter referred
to as CCD). As shown in FIG. 4, each of the photosensitive
cells 104a is provided with a signal reading out gate or
transfer gate 104b connected to a transfer device adjacent
thereto, specifically the vertical transfer device. The signal
10 reading out device 104b is adapted to block the signal charge
converted from the incident light from leaking. The signal
reading out gates 104b transfer the signal charge from the
photosensitive cells 104a to vertical transfer paths 104c in
response to a field shift pulse supplied through the electrodes.
15 The vertical transfer paths 104c transfer sequentially the
signal charge read out in the column direction, that is, in
the vertical direction. The signal charge is supplied to
transfer devices in line direction, that is, horizontal transfer
path 104d, through line shifting. In response to a drive
20 signal, the horizontal transfer path 104d outputs this signal
charge to the signal processing system 10B through an amplifier
104e as described above.

Here, in each of the vertical transfer paths 104c, three
transfer devices are disposed between adjacent two of the
25 photosensitive cells 104a when viewing in the vertical direction
(column direction). The four transfer devices, including the
transfer devices connected to the associated signal reading
out gates 104b, are used for transferring data of a pixel in
one line. Thus, it is proved that four-phase drive signals
30 are supplied as the drive signal for one line transfer. Each
of the signal reading out gates 104b is disposed between one
of the photosensitive cells 104a and one of the vertical
transfer paths 104c.

1 Furthermore, since the arrangement of the photosensitive
cells in the honeycomb-like manner is adopted in which the
respective photosensitive cells are shifted from other
5 photosensitive cells obliquely adjacent thereto by the half
of pitch in the row and column directions, between adjacent
two vertical transfer devices 104c in question, the signal
reading out gates 104b are disposed in such a manner that one
is shifted from the other in the vertical direction by a
10 distance equal to the two transfer devices of the vertical
transfer paths 104b.

Specifically, when the relation in the arrangement between
the two vertical transfer paths 104c is observed, the
photosensitive device of color G corresponds in level to the
15 vertical transfer device V1 in the vertical direction, the
photosensitive device of color R to the vertical transfer device
V3, the photosensitive device of color G to the vertical
transfer device V5, and so on. The basic constitution of the
image pickup device 104 has been described above. With such
20 constitution, the whole-pixel reading out is performed normally.
Thus, the signal charge of all of the photosensitive cells
is read out at a time.

Returning to FIG. 1A, the AF control 106 adjusts the focal
25 position of the optical lens 102 so as to be brought at the
optimum position in accordance with information obtained by
measuring the distance between an object and the camera 10
by the focus adjustment mechanism (not specifically shown).
At this time, an estimation of the information concerning the
30 distance measurement and a control amount from the information
concerning the distance measurement are processed by the system
control 12. As a result, in response to the control signal
12a supplied, the AF control 106 drives the focus adjustment
mechanism in response to the drive signal 106a, so as to move

1 the optical lens 102 along its optical axis in the direction
of the arrow A.

5 Furthermore, the AE control 108 permits the aperture or
iris of the aperture mechanism to be displaced under the control
of an exposure control (not shown) provided in the system
control 12 adapted to estimate the amount or intensity of the
measured light from the object field including the object,
10 thus adjusting the amount of luminous flux incident onto the
photosensitive array. The measurement of light is performed
using a part of the image pickup signal. Also in this case,
the exposure amount is calculated by the system control 12,
based on the amount of measured light. The system control
12 supplies to the AE control 108 the control signal 12a for
15 use in controlling the aperture value and the shutter speed
value so as to mate with the calculated exposure amount. The
AE control 108 supplies a drive signal 108a to the aperture
mechanism and the shutter mechanism in response to the control
signal 12a so as to adjust those mechanisms to the aperture
20 value and the shutter speed value. This adjustment will
optimize the exposure.

25 The signal processing system 10B of FIG. 1B comprises
a pre-processor 110, an A/D converter 112, a signal processor
114, a buffer 116 and a compressor/decompressor 118. The pre-
processor 110 performs, for example, a correlated double
sampling (CDS) for signal charge 10a supplied thereto to reduce
noises, and performs a gamma correction for the signal 10a.
The pre-processor 110 amplifies the signal 10a. Thus, the
30 amplified signal 10a is output to the A/D converter 112.

The A/D converter 112 samples the analog signal 10b
supplied from the image pickup device 104 through the pre-
processor 110, in response to a clock signal 120b supplied

1 display 124 of the signal output system 10D to display the
image representative of the image signal. The signal processor
114 performs a signal processing in the still picture shoot
5 mode so as to convert the digital image signal 10c to a
recordable video signal. Then, the signal processor 114 outputs
to the buffer 116 the signal 10d in the mode in which a
display/record is selected.

10 The buffer 116 has a function to amplify the video signal
10d supplied from the aforementioned signal processor 114 with
a predetermined gain as well as to perform a control on its
time axis in recording. Under the control of a recording
control (not shown) arranged in the system control 12, the
15 buffer 116 outputs the picture signal 10e either to the signal
output system 10D or to the compressor/decompressor 118 or
both.

20 In recording the picture, the compressor/decompressor
118 takes a picture signal 10e thereinto in response to the
control signal 12b of the system control 12. The supplied
picture signal 10e undergoes a compression based on, the Joint
Photographic coding Experts Group (JPEG) standard, for example.
When the signal 10f recorded is read out from the storage 126,
the signal 10f is subjected to a signal processing such as
25 a conversion reverse to the foregoing compression processing,
whereby the original picture signal is reproduced. The restored
picture signal (not shown) is supplied to the display 124 and
displayed thereon.

30 The drive signal generation section 10C includes the signal
generator 120 and a driver 122. The signal generator 120
generates synchronous signals 120b based on clock signals
locally oscillated so as to drive the digital still camera
10 in, for example, a present broadcast system (NTSC/PAL) and

1 supplies the signal 120b to the signal processor 114. The
signal generator 120 supplies the signal 120b as clock signals
for use in generating a sampling signal and a read/write signal
to the pre-processor 110, the A/D converter 112, the buffer
5 116 and the compressor/decompressor 118.

The signal generator 120 generates the synchronous signals
from the locally oscillated clock signals, and, using these
signals, generates a variety of timing signals 120a. The
10 generated timing signals 120a include timing signals used for
reading out the signal charge excited in the image pickup device
104, such as, vertical timing signals which define timings
for driving the vertical transfer paths, horizontal timing
signals which define timings for driving the horizontal transfer
15 paths and timing signals which are used to perform field shift
and line shift. Moreover, the signals from the signal generator
120 are also used for controlling operations of the AF CONTROL
106 and the AE CONTROL 108. The lines conveying those signals
are not illustrated apparently.

20 Thus, the various kinds of signals are output to the
foregoing circuit components, and the signal generator 120
supplies the vertical timing signals and the horizontal timing
signals to the driver 122. When the control signal 12b in
25 the mode of controlling a light measurement (photometry mode)
is supplied from the system control 12 to the signal generator
120, the signal generator 120 supplies a signal for elevating
the substrate voltage of the photosensitive cells, that is,
an overflow drain voltage for the photosensitive cells of the
30 colors R and B, according to demand, for example, in the mode
of controlling a light measurement. The supply of the signal
can bring the photosensitive cells of the color R and B to
the state as if the signal charge would not be generated.

1 Furthermore, in the photometry mode, the signal generator
120 generates a transfer gate signal so as to read out the
signal charge only in the photosensitive cell of the color
G. When the photometry mode is selected, the signal generator
5 120 switches selectively the timing signals responsive to the
control signal 12b from the system control 12.

10 The driver 122 generates the drive signal 122a at the
timings supplied. The rate of reading out the signal is
generally changeable in such a manner that a vertical drive
signal output from the driver 122 in accordance with the mode
selected is supplied to the image pickup device 104 so as to
perform, for example, a drive for the whole imaging area, a
drive for selected colors and a drive for specified colors
15 and region. The driver 122 supplies to the image pickup device
104 the drive signal 122a which is generated associatedly when
the photometry mode is selected in particular and performs
the drive for the whole image area, the drive for the selected
color and the drive for the specified the colors and region
20 to thereby change the reading out rate of the signal.

25 The driver 122 outputs the drive signal 122a which defines
to the timings when the mode is set to the photometry mode.
In an application where the level of the drive signal is
changeable in accordance with the mode, a level switch is
provided to change the level of the drive signal. Generally,
the voltage level to be set is, for example, 1V, 5V, 8V and
12V. The driver 122 generates the drive signal 122a in response
to the timing signal 120a supplied from the signal generator
30 120. The driver 122 generates a tri-level drive signal
including the vertical timing signal and the transfer gate
signal.

The signal output system 10D includes the display 124

and the storage 126. In the display 124, a liquid crystal display monitor of the VGA (Video Graphics Array) standard supplied with inputs of digital RGB signals is provided. The storage 126 is adapted to store the video signal 10f supplied to a magnetic recording medium, a semiconductor memory used for a memory card, an optical recording medium or a magneto-optical recording medium. Moreover, the storage 126 is also capable of reading out the video signal 10f thus stored so to be displayed on the display 124. With the type of storage 126 in which the recording medium is detachably mounted the recording medium may be detached so as to reproduce the video signal recorded on the recording medium by an external apparatus to display and/or print the picture.

The mode setting section 10E includes a release button 128 and key switches 130. In this embodiment, a two-stroke button mechanism is provided in the release button 128. Specifically, in the half-depressed state as the first stroke, the photometry mode is set to develop a signal representing the photometry mode set to the system control 12. In the fully-depressed state as the second stage, the signal defining the timing for taking the picture is supplied to the system control 12 to notify the system control 12 of fact that the picture recording mode, or the still picture shoot mode, was selected. The settings of these modes are reported to the system control 12 on a signal line 28. Furthermore, when the shutter release button 128 is in its state of powering the camera 10 on and a switch (not shown) of the image monitoring display is in its ON state, the system control 12 based on the signal supplied through the release button 128 controls the display 124 so as to display a moving picture in the moving picture mode.

The key switches 130 is a cross-shaped key, which selects items and picture images by moving a cursor in all directions

1 (e.g. up-/down-ward/right-/left-ward), which is displayed on
the screen of the display 124. The selected information is
also sent to the system control 12 on a signal line 30.

5 The system control 12 is adapted for controlling the
general operation of the camera. The system control 12 includes
a central processing unit (CPU). The system control 12 decides,
based upon the input signal 28 from the release button 128,
which mode is selected. Furthermore, the system control 12
10 controls the processing on the picture signal of the camera
by selection information 30 from the key switches 130. Based
on the supplied information, the system control 12 controls
the operation of the drive signal generation section 10C based
on the supplied information. The system control 12 includes
15 a recording control (not shown). The recording control controls
operations of the storage 126 of the signal output system 10D
and the buffer 116 in response to a timing control signal 12c
from the system control 12.

20 The operation of the digital still camera 10 constructed
as described above will be described. First, in the operation
of the whole-pixel reading out normally performed, since the
digital still camera 10 is usually of the type having the image
pickup device 104 capable of the whole-pixel reading out,
25 the notification of the still picture shoot mode set from the
release button 128 allows incident light passing through the
color separation filters CF arranged in the honeycomb type
G square lattice RG complete checkered pattern to be received
by entire photosensitive cells 104a. Upon receipt of the
30 incident light, each of the photosensitive cells 104a converts
the photoelectric charge excited by the incident light to store
the signal charge therein.

In order that the stored signal charge is read out from

each of the photosensitive cells 104a, the signal generator 120 generates the vertical synchronous signal VD as shown in FIG. 5. Furthermore, the signal generator 120 generates vertical timing signals V_1 to V_8 supplied to transfer devices V1 to V8 of the vertical transfer path 104c in synchronization with the vertical synchronous signal VD and transfer gate signals TG_1 , TG_3 , TG_5 and TG_7 supplied to the signal reading out gate 104b. In FIG. 5, it is schematically illustrated that during each of the vertical synchronous periods, the vertical timing signals V_1 , V_4 , V_5 and V_8 are negative signals, and the vertical timing signals V_2 , V_3 , V_6 and V_7 are positive signals. It is understood that the transfer gate signals TG_1 , TG_3 , TG_5 and TG_7 are generated so as to read out the signal charge in synchronization with the vertical synchronous signals VD input from the respective photosensitive cells.

That timing relation, when depicted in an enlarged scale with respect to time is understood as shown in FIG. 6. Specifically, it is shown that in this stage, the signal charge is read out only from the photosensitive cells at the positions associated with the vertical timing signals V_1 and V_5 when the transfer gate is turned on, and a field shift is not performed until a next vertical synchronous signal VD is supplied (see also FIG. 5). Then, after the field shift, the vertical timing signal is sequentially supplied in synchronization with the horizontal synchronous signal HD. With this supply, the signal charge shifted to the vertical transfer path 104c is transferred toward the horizontal transfer path 104d.

The vertical timing signals and the transfer gate signals, following the vertical synchronous signal VD changed to its level "H" in the timing as shown in FIG. 6, and the horizontal synchronous signal HD gone positive thereafter are illustrated in FIG. 7, which is shown as enlarged with respect to time.

1 Particularly, when the vertical timing signals V1 and V5 and
the transfer gate signal TG₁ and TG₅ are supplied to the driver
122, vertical drive signals ϕV_1 and ϕV_5 shown in FIG. 7 are
output to the image pickup device 104. Upon the output of
5 the vertical drive signals ϕV_1 and ϕV_5 , the potentials as shown
in FIG. 7 are formed in the vertical transfer devices V1 and
V5. Moreover, since the transfer gate signals TG₃ and TG₇ become
the ON state thereof, the vertical drive signals ϕV_3 and ϕV_7 ,
as shown in FIG. 7 are generated. Thus, the potentials are
10 formed as shown in FIG. 7.

Furthermore, the procedures in which the signal charge
shifted to the vertical transfer path 104c is transferred toward
the horizontal transfer path 104d are understood from the timing
15 chart of FIG. 8. The vertical transfer path 104c is illustrated
in the form of eight vertical transfer devices V1 to V8. It
is found that there are two groups in the vertical drive
signals, and the same signals are commonly supplied to the
vertical transfer devices V1 to V4 and the vertical transfer
20 devices V5 to V8. Specifically, the vertical transfer devices
V1 to V4 and the vertical transfer devices V5 to V8 are driven
by the four signals in different phases. The signal charge
vertically transferred is subjected to the line shift, and
thereafter the signal charge is sequentially on the horizontal
25 transfer path 104d. Thus, the signal charge of all pixels
is read out from the image pickup device 104 within a
predetermined period at a time.

By the way, the general image pickup procedures in the
30 digital still camera 10 will be described. In the digital
still camera 10, a light measurement is first performed for
an object field prior to an image pickup. At the time of
photographing the object field, the release button 128 is made

1 to be in its half-depressed state, thus setting the mode of
controlling a light measurement. In this case, among signals
obtained by the photoelectric conversion in the image pickup
device 104 of the image pickup system 10A, the signals of the
5 color G are taken out. This is because the automatic focusing
(AF) can be controlled only by the information relating to
the signal of the color G occupying about 70 % of the luminance
information. Furthermore, since the pixel information must
be read out many times in the light measurement in the AF until
10 a proper value is determined, there is a demand for reading
out the signal charge as fast as possible.

On the other hand, when the controls for the AE and the
AWB are performed, information relating all colors is required.
15 Accordingly, reading out of the information relating to
monochrome, that is, the color G, is purposeless. A high-speed
reading out of the signals by the drive signal is performed
when picking up an image, which will be later described in
detail.

20 The picture signal 10a obtained by the image pickup system
10A during the light measurement is supplied to the signal
processing system 10B in the form of the control signal 12a
from the system control 12. The signal processing system 10B
25 converts the supplied picture signal 10a to a digital signal.
The image data obtained by the conversion is supplied to the
system control 12 as light measurement information (not shown).
The system control 12 performs a computation on this light
measurement information. By this computation, the system
30 control 12 generates an AF control signal (or control
information) 12a, and outputs it to the AF control 106. The
AF control 106 performs an adjustment in accordance with the
supplied control signal 12a through its mechanism built therein.
This adjustment is iterated in this mode.

1 Thereafter, the user changes the release button 128 to
its fully-depressed state at a desired image pickup timing.
In response, a signal for recording the image of the object
in the object field is supplied to the system control 12.
5 An image pickup with the incident light from the object field
is carried out by the image pickup system 10A similarly to
the previous mode. It should be noted that in the still picture
shoot mode (the whole-pixel reading out), the signals of the
colors RGB are taken in. Before this image pickup, a drive
10 signal to be supplied is naturally different from that in the
previous reading out of the signals. The picture signal 10a
picked up is converted to a digital signal 10c by the A/D
converter 112 of the signal processing section 10B, and then
supplied to the signal processor 114.

15 The signal processor 114 processes the image data
represented in the form of luminance and chrominance signals
into the signals extending to a higher frequency. Then, the
obtained image data is supplied to the compressor/decompressor
20 118 through the buffer 116. The compressor/decompressor 118
performs a compression processing, and produces a resultant
signal 10f to the signal output system 10D. In the still
picture shoot mode, the image data 10f of all pixels supplied
under the control of the recording control section in the system
25 control 12 is recorded in the storage 126. The storage 126
is also capable of reading out the recorded image data under
the control of the recording control section.

30 As described above, the digital still camera 10 can operate
both in the photometry mode and in the still picture shoot
mode by the release button 128. In the case where the digital
still camera 10 performs an image pickup with the large number
of pixels exceeding, for example, a million, in the still
picture shoot mode the time is not so critical which is required

1 for reading out all pixels of the image pickup signals except
for a continuous shooting. However, the mode of controlling
a light measurement requires shortening a reading out time
in performing the AF control as described above. In an
5 application of digital still camera 10 using the image pickup
system 10A accomplishing such requirements, operations of the
image pickup device 104 and the drive signal generation section
10C in the mode of controlling a light measurement for the
AF control will be described.

10 Since the arrangement of the color separation filters
CF adopts the honeycomb type G square lattice RB complete
checkered pattern, it is understood that the photosensitive
cells 104a of the color G are arranged to be adjacent to the
15 vertical transfer devices V1 and V5 as is apparent in FIG.
4. When only the signal charge of the photosensitive cells
of the color G occupying the larger part of the luminance
information are read out, it suffices that the transfer gate
signals TG_1 and TG_5 are supplied so as to turn on the signal
20 reading out gates 104b adjacent to the vertical transfer devices
V1 and V5. This timing relation is shown in FIG. 9. Since
other transfer gate signals TG_3 and TG_7 are in the level "H"
thereof, the signal reading out gates 104b adjacent to the
vertical transfer devices V3 and V7 are kept disabled, and
25 the signal charge of the photosensitive cells of the colors
R and B cannot therefore be read out. The signal charge is
read out from the photosensitive cells G1 and G2 onto the
vertical transfer paths 104c in this timing relation, as shown
in FIG. 10A. The signal charge read out onto the vertical
30 transfer paths 104c is transferred to the horizontal transfer
path 104d sequentially, as described above. At this time,
all of the signal charges in the vertical transfer paths 104c
are allowed to move downward by a transfer distance equivalent
to two horizontal lines. As a result, the signal charge of

1 the photosensitive cells G1 which are closest to the horizontal transfer path 104d is supplied to the horizontal transfer path 104d.

5 Accordingly, with respect to the signal charge of the photosensitive cells G1, the movement of the second one of the two lines is a line shift. Since the signal charges of the photosensitive cells of the colors R and B are not read out, transfer devices which would otherwise be supplied with
10 these signal charges are illustrated by a symbol E (emptiness or lack of signal charge), see FIG. 10B.

Next, the signal charges G1, E, G1, E,..., which arrived at the horizontal transfer path 104d, are transferred to the
15 amplifier 104e (FIG. 4) arranged on the output side, and output therefrom, sequentially. Thereafter, all of the signal charges left in the vertical transfer paths 104c are made to move downward by a transfer distance equivalent to the two lines again (see FIG. 11A). Then, the signal charges G1, E, G1,
20 E,..., which arrived at the horizontal transfer path 104d, are sequentially transferred to the amplifier 104e arranged on the output side, and output therefrom (see FIG. 11B).

Only the signal charges of the photosensitive cells of
25 the color G illustrated with the hatching in FIG. 12 are read out by the transfer of the signal charges. As is apparent from the arrangement of FIG. 12, the 1/2 thinning is performed by thinning every other one out of the photosensitive cells in the horizontal and vertical directions. However, in this
30 arrangement in the honeycomb-like manner, the respective photosensitive cells are shifted from other photosensitive cells obliquely adjacent thereto by the half pitch in the row and column directions.

1 This implies that the number of the pixels actually read
out is not equal to the number of the pixels by 1/4 thinning
when every other one out of the pixels is thinned in the
horizontal and vertical directions. By performing no reading
5 out operation of the signal charge to the vertical transfer
device, the vertical transfer device expressed by the symbol
E can be treated in the same manner as the transfer device
to which the signal charge is actually transferred without
any distinction.

10 In other words, although the signal charge "E" can be
neglected in the vertical transfer, the transfer is performed
as if the signal charge "E" were treated as the charge "E"
occupying the position of one transfer device in the transfer
15 in the horizontal direction. For this reason, the number of
the transfer stages in the horizontal direction is the same
as where the thinning is not performed. (see FIG. 10C and FIG.
11B).

20 Accordingly, the reading out of the signal charge was
investigated so that the number of the transfer stages in the
horizontal direction becomes equal to that when the 1/2 thinning
is performed. As a result, the reading out of the signal charge
is performed according to the following procedures. The signal
25 charge is read out as shown in FIG. 13A. The procedures of
reading out the signal charge are the same as shown in FIG.
10A. In the next vertical transfer, the signal charge read
out on a two-by-two line (two stages) basis is totally
transferred similarly to FIG. 10B (see FIG. 13B). The
30 procedures up to this point are the same as in the previous
by described procedures.

Next, the horizontal transfer will be described. The
signal charge is moved by two stages on the transfer path 104d

in the controlling operations will be described using the color G, and a method to realize the reading out of the signal charge at a faster speed will be described. As a light measurement range required for performing the AF control, a region near the center, and not the entire, of the photosensitive cell array is satisfactorily used. The region near the center of the array is a region 104f illustrated by the hatching in FIG. 15, and the region 104f occupies an area ranging from at least a quarter to half of the entire array, roughly. The reason why the light measurement range is set to such a region is that an object is often disposed near the center of the imaging field based on experience when a user considers a composition of the imaging field.

In order to read out only the signal charge of the color G in this specified range 104f selectively, it suffices that the signal charge can be read out from the photosensitive cell 104a in this specified range 104f. For this reason, the signal charges to be supplied are separately treated so as to distinguish the specified range 104f from the other ranges. Drive signals ϕV_{1a} and ϕV_{5a} are supplied to the ranges other than the specified range 104f so as to distinguish themselves from the drive signals ϕV_1 and ϕV_5 . On the other hand, drive signals ϕV_{1b} and ϕV_{5b} are supplied to the specified range 104f so as to distinguish themselves from the drive signals ϕV_{1a} and ϕV_{5a} . In addition, with respect to the signal lines to which the drive signals ϕV_{1b} and ϕV_{5b} are supplied, the signal line connected to the specified range 104f and the signal lines connected to the remaining ranges are perfectly individually arranged from each other.

An operation in this case will be described with reference to FIGS. 17 to 19 briefly. When the signal charge of the color

in the horizontal direction. Therefore, in order to keep the signal charge, the horizontal transfer path 104d is constructed so that includes at least two extra transfer devices. As a result, the signal charge "E" of the colors R and B is sent to the region just below the vertical transfer path for transferring the signal charge of the color G (see FIG. 13C). Thereafter, the same vertical transfer as described above is performed. Thus, the signal charge left is transferred downward on two-by-two stage basis. Although the signal charges of "E" of the colors R and B exist in the region just below the vertical transfer path for transferring the signal charge of the color G, without mixing colors even when the signal charge of the color G is transferred thereto because the region just below the vertical transfer path is inherently empty "E" Accordingly, the signal charge of the color G2 fills the region with the signal charges of the colors R and B without producing mixed color.

As a result, the signal charge of the color G for the two lines is held in the horizontal transfer path 104d (see FIG. 13D). In the horizontal transfer after the second vertical transfer, the signal charges G1, G2, G1, G2, ... of the color G for the two lines are read out from the horizontal transfer path 104d at a time. The signal charges for two lines are read out in a normal period of time for reading out the signal charges for one line (see FIG. 14). Specifically, the 1/2 thinning in the horizontal direction will be performed.

By processing according to the above described procedures, since the 1/2 thinning is performed in the horizontal and vertical directions, the time required can be easily shortened to 1/4 as long as the whole-pixel reading out.

Here, the AF control in which a high speed is most required

1 G is read out from the region 104f near the center of the
imaging array, the drive signals ϕV_{1a} and ϕV_{5a} are supplied to
the vertical transfer devices V1 and V5 arranged in parallel
with the region 104f. These drive signals ϕV_{1a} and ϕV_{5a} are
5 prepared from the vertical timing signals V_1 and V_5 and the
transfer gate signals TG_{1b} and TG_{5b} shown in FIG. 17.
Particularly, the transfer gate signals TG_{1b} and TG_{5b} are
independently generated, and these timing signals are supplied,
separately. In this case, the transfer gate signals TG_{1a} and
10 TG_{5a} are not generated.

Of the time regions including the vertical synchronous
signal VD of the FIG. 17 scaled up, the vertical timing signals
and the transfer gate signals are illustrated in the timing
15 chart of FIG. 18. The vertical timing signals V_1 to V_8 are
the same as the foregoing vertical timing signals of FIG. 6.
Moreover, with respect to the transfer gate signals, the
transfer gate signals TG_1 and TG_5 are used separately for the
two regions. In this figure, since the signal charge is read
20 out only from the specified region 104f, the signal charge
is read out only for the vertical transfer devices V1 and V5
to which the transfer gate signals TG_{1b} and TG_{5b} are supplied.
In the above-described manner, the range for reading out the
signal charge is defined.

25 Moreover, the time region near the transfer gate signals
 TG_{1b} and TG_{5b} of FIG. 18 are illustrated in an enlarged scale
in FIG. 19. The vertical timing signal V_1 and the transfer
gate signal TG_{1b} , and the vertical timing signal V_5 and the
transfer gate signal TG_{5b} are supplied from the signal generator
30 120 to the driver 122. The driver 122 uses each of those sets
to generate the drive signals ϕV_{1b} and ϕV_{5b} . The drive signal
122a is supplied from the driver 122 to the image pickup device

1 104.

5 As shown in FIG. 16, the signal charge read out only from the specified range is transferred to the vertical transfer devices V1 and V5 forming to the specified range 104f of the vertical transfer paths 104c from the photosensitive cells 104a via the signal reading out gates 104b. Here, in FIG. 16, in order to emphasize that the drive signals ϕV_{1b} and ϕV_{5b} are independently supplied to the vertical transfer devices V1 and V5, the one wiring is shown for each the signals ϕV_{1b} and ϕV_{5b} . If other vertical transfer devices V1 and V5 exist in the specified range 104f, as a matter of course the drive signals ϕV_{1b} and ϕV_{5b} are also supplied to those vertical transfer devices V1 and V5.

15 The signal charge obtained in the above-described manner is vertically transferred. The foregoing improved horizontal transfer performed causes a faster reading out of the signal charge to be performed. For example, the specified range at least required for reading out the signal charge is reduced to a quarter of the entire imaging array, and the 1/2 thinning in the reading out of the signal charge is performed in the horizontal and vertical directions including the improved horizontal transfer. Thus, the signal charge can be read out only in a time of $1/4 \times 1/2 \times 1/2 = 1/16$ as long as the time for reading out period the entire pixels in the specified range 104f.

30 With the above described constitution, the present situation in which the trial to meet the demand for a high-density integration of the pixels obstructs antinomically the high speed reading out of the signal charge can be comparatively easily solved. Thus, the present invention can be used for

the AF control which requires the fastest reading out of the signal charge from the image pickup device. Since the image pickup devices serves as a photosensitive sensor, a dedicated light measurement sensor can be omitted.

The entire disclosure of Japanese Patent Application No. 20028/1999 filed on January 28, 1999 including the specification, claims, accompanying drawings and abstract of the disclosure is incorporated herein by reference in its entirety.

While the present invention has been described with reference to the particular illustrative embodiments, it is not to be restricted by those embodiments but only by the appended claims. It is to be appreciated that those skilled in the art can change or modify the embodiments without departing from the scope and spirit of the present invention.

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